and burning the exhaust as fuel; but when in flight, the force of the wind extinguished the flame.

It was clearly seen by the experiment that for practical commercial success of this class of steam apparatus an air condenser is essential, as the weight of water used in a few minutes' run equals the total weight of engine and boiler. Without a condenser, the length of flight must necessarily be limited to a very few miles, and it would seem that the chief problem that workers in this field have to solve, is to obtain an efficient and light dry air condenser. CHARLES A. PARSONS.

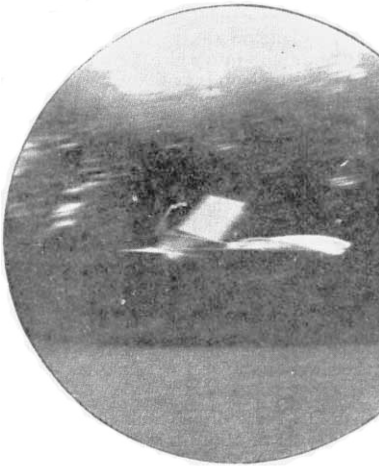

FIG. 2.—Same engine and boiler as before, attached to two inclined wing planes, and tail. From tip to tip of wings 11 feet; total surface of wings and tail about 22 square feet. Total weight of whole apparatus 3½ lb. Steam raised to 50 lb. per square inch, and started. Length of flight about 100 yards on level; maximum height during flight, about 20 feet. The propelling screw is seen in front and above the frame.

Heaton Works, Newcastle-on-Tyne.

Experiments on Röntgen Rays.

AFTER examining the fluorescent and photographic action of the rays (X_2) emitted on strongly *heating* a "focus tube," and finding them different to the rays which have been hitherto noticed (X_1), in that the relative transparency of flesh, bone, aluminium and glass differs for the two kinds of rays, it seemed desirable to try the effect of cooling the tube. Solid carbon dioxide and ether, and then solid carbon dioxide alone were employed, with the result that in both cases the fluorescence of screen and tube very rapidly died out and the current apparently failed to pass through the latter; as the tube gradually grew warm again, the fluorescence in it returned, not gradually, but very suddenly, at a temperature not very far below that of the room, the glass lighting up brilliantly, and the shadows of the bones showing on the screen with increasing distinctness. The emission of X_1 rays reaching a maximum at about 12° C. (a rough guess). On further heating X_2 rays begin to be evolved, judging from the increasing opacity of the flesh, whilst at the same time the fluorescence excited on the screen grows rather brighter, until the state recorded in my paper of June 4, is reached. As the condition for the maximum of X_1 rays probably varies to a certain extent with the different forms of tube, and even different specimens of the same kind of tube, with the degree of exhaustion, &c., it seems to follow from these experiments that in some cases warming the tube slightly might be useful in photographing the bones, whilst in others moderate cooling would be better; and from the accounts of various operators such would seem to be the case, though, as will be seen in the light of subsequent experiments, the particular method of heating or cooling is an important factor in the result. Solid carbon dioxide seemed very opaque to the rays when its low density is considered, but the effect may have been partly due to the frost condensed upon it from the air.

Wishing to verify for myself the results of other experimentalists, I next examined the tube for its action on a well-insulated brass plate, at first by connecting it with a sensitive electroscope, and afterwards with one of the standard Thomson's quadrant electrometers. As the experiments were all carried out with great care, it may be worth while to state that, using thin aluminium plate well earthed by soldering to a gas-pipe to screen the plate from all ordinary inductive action, the results were that the rays after penetrating $\frac{1}{30}$″ of aluminium, discharged the plate completely, whether electrified positively or negatively, leaving no charge; and that if the plate were uncharged to begin with, it remained uncharged. This result is contrary to that observed by some; but from the delicacy of the instrument used, and the great distance between mirror and scale, there is little room left to doubt the accuracy of this result.

I also tried the effect on a radiometer, making similar experiments with a lampblacked Leslie's cube at about 94° C., and a candle, to see how far radiant energy from these sources was capable of penetrating the large aluminium screens used, in case any heat action might interfere with or mask the effect, and found, as others have, that when perfectly screened from all other action, the radiometer is entirely unaffected by the Röntgen rays, whether they be from a hot or a cold tube. The X-rays are also without action on the blackened face of a thermopile connected with a very sensitive galvanometer.

When the ordinary inductive effects of the tube were *not* screened, I found that the space external to the tube was at a high positive potential, which increased up to contact with the glass of the tube, and was of the same sign all over the bulb part. The cold bulb acted like a positively charged conductor whilst the discharge was passing, and attracted the radiometer arms just as any other charged body would, the effect lasting some time after the discharge stopped. The *unscreened* cold bulb also partly discharged the insulated plate, if the latter were strongly positively charged, it more rapidly discharged it when negatively charged, and left it with a positive charge of the same magnitude to begin with as that left when the plate was strongly positively charged, and lastly in the uncharged plate it developed a positive charge, again of the same magnitude; and this is what would naturally follow from the combination of the Röntgen rays effect with that of ordinary induction.

The X_2 rays seem to discharge a charged plate whether positively or negatively charged, but of this I cannot at present feel quite sure. Aluminium seems so far opaque to them that it is doubtful whether, when a screen is used, any of the rays get through, and when a screen is not used, one cannot feel certain that the effect observed is due to the X_2 rays either wholly or partly. After heating the tube and turning on the current, the whole tube is filled with a whitish, lavender-coloured light, which comes to a focus on the glass behind the kathode, above or below it; and whilst in this state and giving little or no fluorescence on the screen, the tube does *not* charge an *unscreened insulated plate*, but it does rather rapidly drain it of a previously communicated charge, either positive or negative. As the tube cools the lavender light retreats more and more from the kathode till at last it reaches the upper edge of the rectangular anode, when the positive charge, mentioned before, begins to be given to an uncharged insulated plate, but very slowly; as soon as the centre of the anode is bare of the lavender discharge, the potential of the unscreened plate very rapidly rises, and by the time the whole anode is clear of the lavender light the normal positive charge is re-established on the insulated plate. When the lavender glow retires from the kathode, it leaves behind it a space full of almost invisible light, which excites whitish green fluorescence on the glass of the bulb, and it is during this time that most of the rays are X_2, as is shown by the fluorescent screen, and photographs of a hand. I have not yet followed out the changes, relative and absolute, of potential of the anode and kathode, but it would seem almost certain that during the life of the lavender glow the whole tube acts as a relatively good conductor up to the time when the lavender glow crosses the centre of the anode—or the point where the axis of the kathode mirror cuts the anode, when there is an abrupt decrease in conductivity. I intend to investigate this point as soon as possible, and meantime pass on to what I imagine will prove of great use and interest to all who work with these tubes.

During some experiments on the tube with an 18″ Wimshurst machine, I noticed that the X_1 rays, *i.e.* those showing the bones best, seemed to be emitted or not according as a brush discharge occurred on the wire leading to the anode of the tube, close to the tube, or not; and that the "electric wind" which blows from the tube as from all charged bodies, seemed also to vary in intensity with the X_1 ray flashes, the X_1 rays being most copiously emitted apparently at the moment when the brush discharge ceased or the wind moderated. I soon found that by making a small brush on the wire near the anode, or drawing

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one with the finger from various parts of the tube (but not from all), best from the circular section of the tube in a plane with the edge of the kathode mirror, or in the very immediate neighbourhood of this line, the discharge producing the X_1 rays could be induced at will in a tube which was not otherwise giving them, or at any rate only giving them very feebly. Thinking, therefore, that the production of the X_1 rays must be in some way connected with intermittent leakage of the charge which resides on the outside of the tube (a continuous drain stops fluorescence and the emission of any rays capable of exciting my fluorescent screen altogether), I tried various ways of drawing off this charge intermittently, with several curious results; but the plan I find to work best is to place a ring of plain copper wire round the tube in the plane of the kathode mirror's edge, not touching the glass, but very near it, and then to cause a very rapid but intermittent discharge by bringing a wire connected to earth within a *very small* distance of some part of this ring, so far I cannot discover any particularly favourable position. The sparks between this ring and the earth wire are very small, but the effect on the fluorescent screen exceedingly striking.

What is still more interesting is that not only is the discharge of X-rays made much more regular (when the adjustment of the ring and wire is carefully made), but *the X-rays can thus be induced in a tube with a far weaker current;* the weakest current capable of inducing sparks between the ring and conductor seems capable of giving the X-rays, though they are more copiously emitted with a stronger current.[1] And not only so, but the tubes I have experimented with seem to show as yet no symptoms of growing fatigued. I have caused a brilliant emission of the X-rays from a tube which was before "fatigued"—at least, my coil seemed too weak to excite it, and the emission of X_1 rays has been sustained for over two hours with but a few short intervals, without showing any signs of diminution, judging by the screen effects; but on the withdrawal of the ring and wire, it at once failed to give any. This seems an important result, for it must greatly shorten the exposure and fatigue necessary for the photography of thick objects, and also greatly save the expense of the operations. Even breathing very gently, or blowing gently for a moment on the tube, specially on the parts mentioned, produces a marked bright flash which on examination will prove very rich in X-rays (a fact first noticed by Mr. P. H. Walter, my assistant). It would seem to follow from this that the "fatigue" is not altogether due to the diminution of the number of free particles in the tube, but to a kind of polarisation in which the glass acts as the dielectric separating a negative charge inside from a positive outside, the X-rays and fluorescence being dependent in some way on the oscillations consequent on the intermittent discharge of this condenser. I find that the tube also gives X-rays plentifully (though not so plentifully as when *both* terminals of the secondary circuit are used), when the positive terminal of the coil is connected in the usual way, and a wire from earth leads to what is usually the kathode; but only, so far as my experiments go, when the ring and other earthed wire are used. In this experiment the negative terminal was *not* connected with the earth, but insulated. The tube did not give X-rays, scarcely indeed any sign of the passage of electricity when the kathode wire only was retained in its usual position. The positive anode therefore seems in some respects to govern the emission of these rays.

In one experiment I placed a ring round the glass in the plane of the concave mirror of a Crookes' tube showing the "independence" of the positive pole from which I could not get any X-rays, and found on extracting a series of small sparks from it, with a wire leading to earth, a very decided increase in the still general fluorescence of the tube, but it gave no rays. Incidentally it was noticed that when a wire brush connected to earth was pressed lightly against the glass over the dark spot opposite the kathode, in every place touched by the wire, a most brilliant green fluorescence was excited, which faded away very quickly when the brush was withdrawn. It is therefore certain that much may yet be done to increase the efficiency of the tubes used for the production of X-rays by a further study of the action of neighbouring conductors upon them, and it seems that such a study cannot fail to throw light upon the cause of these hitherto unexplained phenomena.

Eton College, June 8. T. C. PORTER.

Addendum, June 13.—After trying various forms of conductor, coating different parts of the X-ray tube with Dutch gold, and aluminium leaves, I find the following a most effective plan, and feel no hesitation in recommending it. First coat the external part of the tube between the kathode wire loop and the afore-mentioned plane of the edge of the kathode mirror, with any conducting metallic leaf; being careful that none of it projects beyond the trace of this plane on the glass of the tube. Next coil a stout piece of copper wire into a circular loop with a stem, and place it so that whilst the loop is in the plane of the edge of the kathode mirror, it does not touch either the glass of the tube or the metallic coating—I find an interval of about the $\frac{1}{20}$th of an inch answers excellently; and lastly, instead of using a wire to earth, bring the stem of the looped wire, or better still, a more pliable piece of wire connected with the loop stem, within a very short distance of the part of kathode wire from the coil close to the tube. The adjustment is easily made in practice, and the emission of X_1 rays which follows will, I think, be found satisfactory, to say the least, especially when it is remembered that without the looped wire the tube may be giving no X-rays at all.—T. C. P.

Koch's Gelatine Process for the Examination of Drinking-Water.

I DO not find that Dr. Percy Frankland advances any substantial evidence in his letter of May 12, in support of his broad and unqualified claim that he was the first person in this country who adopted the Koch method and applied it to the London water supply.

Dr. Percy Frankland states that he has "failed to find in Dr. Angus Smith's publications any mention whatsoever of cultivation on plates or their equivalents in any shape or form," and which he "holds to be the essence of the process which bears the name of Koch, and to which modern bacteriology is so profoundly indebted."

Now if Dr. Percy Frankland will turn to page 28 of Dr. Angus Smith's report to the Local Government Board, he will find Dr. Angus Smith writing as follows:—"It may be better to give up test-tubes entirely—equally good results have been obtained by using other vessels." As a matter of fact, photographic glass-plates were used in some of Dr. Angus Smith's experiments, also flat-bottomed flasks, desiccators, &c.; consequently if Dr. Percy Frankland's contention is correct, that the essence of the process which bears the name of Koch consists in the use of plates or their equivalents, Dr. Angus Smith at all events can be credited with having adopted the essence of the process. The main value, however, of Dr. Koch's invention was in the use of gelatine for preserving, as Dr. Angus Smith said, "the indications of organic vitality, and of affording an opportunity for the expansion of living germs in water, keeping a record for a time both of the quality and intensity of life in the liquid, and enabling the smallest points to exert their energies, and, as it were, to build their structures, the size and numbers of which can to some extent be measured and counted"

Dr. Koch was the first to use gelatine, and it was from him Dr. Angus Smith learned its use; for he says, "I seized on the use of gelatine with great earnestness, and soon satisfied myself that there was much to be gained by its use. . . . Dr. Koch has himself informed me that he is glad I have taken up the subject . . . a subject being more fully developed under Dr. Koch by Dr. Rozahegyi, and chemists must prepare for a new condition of things."

With regard to Dr. Percy Frankland's statement that Dr. Angus Smith distinctly deprecated rendering the medium more nutritive, I do not agree with it, inasmuch as Dr. Angus Smith clearly stated that "experience must discover whether this is an advantage . . . the use of sugar in addition to the gelatine renders the examination of water by this method less dependent on the opinion of the operator, and a photograph may be taken of each specimen, and the result preserved as evidence."

Whilst wishing in no way to detract from the value of the work which has been done by the use of the modified Koch's process, and from developments of bacteriological methods since the investigation of Dr. Angus Smith, I believe that I have quoted sufficient evidence to show that Dr. Angus Smith was the first chemist in this country who "seized on" and applied to practical purposes Dr. Koch's gelatine process of 1881; and his name will ever be associated with the historical development and application of Koch's gelatine process in this country; and

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[1] I have succeeded in eliciting feeble X-rays from a Newton's focus tube with a small coil giving only 1/3rd of an inch spark—using the ring and earthed wire or finger.

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